BULLETIN

OF THE INSTITUTE OF METALS

VOLUME 5 JUNE 1960 PART 10

WEST OF ENGLAND AUTUMN MEETING

Bath, Monday to Friday, 5–9 September 1960

As previously announced, the 1960 Autumn Meeting will be held in the West of England from Monday to Friday, 5–9 September. The scientific and technical sessions will be held in Bath, from which the visits arranged in connection with the meeting will start. An influential Reception Committee has been formed, under the chairmanship of Mr. D. M. G. SNEDDON, General Manager, Imperial Smelting Corporation, Ltd., Avonmouth.

PROVISIONAL PROGRAMME

Monday, 5 September

3 p.m. Opening session, followed by tea in the Pump Room.

4 to 6 p.m. *Two Simultaneous Scientific Sessions* for the discussion of papers published in the *Journal*, or otherwise, in advance of the meeting:

A.—*A Discussion on "Engineering Properties of Nickel-Base Alloys"*, based on the following papers:

(1) "A Study of the Thermal-Fatigue Behaviour of Metals: The Effect of Test Conditions on Nickel-Base High-Temperature Alloys", by E. Glenny and T. A. Taylor (*Journal*, Serial No. 2010, July 1960).

(2) "Intergranular Cavitation, Structure, and Creep of a Nimonic 80A-Type Alloy", by C. W. Weaver (*Journal*, Serial No. 1986, March 1960).

The Guildhall Banqueting Room, Bath.

(3) " The Influence of Heat-Treatment and Composition on the Microstructure and Creep Behaviour of a Nimonic 80A-Type Alloy ", by C. W. Weaver (*Journal*, Serial No. 2011, July 1960).

B.—*A Discussion on " Lubricants for Cold Rolling Aluminium "*, based on the following paper:

" Development of Cold-Rolling Lubricants for Aluminium Alloys ", by R. D. Guminski and J. Willis (to be published in August).

6.30 p.m. *Cocktail Party* in the Pump Room.

Tuesday, 6 September

10.0 a.m. *Two Simultaneous Scientific Sessions* for the discussion of papers published in the *Journal*, or otherwise, in advance of the meeting.

A.—*A Discussion on " Recovery and Recrystallization "*, arranged by the Metal Physics Committee and based partly on the following paper:

" The Recrystallization Characteristics of Dilute Aluminium Solid Solutions Prepared from Zone-Refined Aluminium by Levitation Melting ", by J. C. Blade, J. W. H. Clare, and H. J. Lamb (*Journal*, Serial No. 1995, April 1960).

B.—*Discussions of Two Papers:*

(i) Properties of Metals at Low Temperatures.
(ii) " Improvement of the Age-Hardening Properties of Magnesium–Rare-Earth Alloys by the Addition of Silver ", by R. J. M. Payne and N. Bailey (*Journal*, Serial No. 2005, June 1960).

Afternoon. *Visits* for members and ladies.

Evening. *Reception* (dancing and light refreshments) by invitation of the civic authorities of Bath.

Wednesday, 7 September

All day. *Visits* for members and ladies.

Evening. Free.

Thursday, 8 September

10.0 a.m. *Two Simultaneous Scientific Sessions* for the discussion of papers published in the *Journal*, or otherwise, in advance of the meeting:

A.—*A Discussion on " The Relative Merits of Extrusion and Other Methods for the Manufacture of Bar, Rod, and Wire-Rod "*, based on the following paper and one or two other papers that may be published in advance of the meeting:

" The Manufacture of Bar, Rod, and Wire-Rod in Copper and Copper-Base Alloys: A Comparison Between Extrusion and Other Methods ", by K. Gering and G. Wilson (*Journal*, Serial No. 1943, Oct. 1959).

B.—*A Discussion on " Magnesium Alloys for Fuel-Element Components "*, arranged by the Nuclear Energy Committee and based on the following papers to be published in the *Journal* in advance of the meeting:

(1) " The Creep and High-Temperature Fatigue Properties of the Magnesium-Base Canning Alloy Magnox A12 ", by P. E. Brookes, N. Kirby, and W. T. Burke.
(2) " Creep-Resistant Magnesium Alloys for Nuclear Fuel Elements ", by G. E. C. Olds and G. M. Michie.

Afternoon. *Visits* for members and ladies.

Evening. *Dinner* in the Guildhall Banqueting Room.

Friday, 9 September

10.0 a.m. *Autumn Lecture* by Professor Sir ALFRED PUGSLEY, F.R.S.
Final business session; votes of thanks.

Hotel Accommodation

There are no really large hotels in the Bath area; in consequence, it is unavoidable that those attending the meeting must be accommodated in quite a number of hotels in Bath and the surrounding country or in Bristol.

Copies of a printed booklet " Holiday Accommodation at Bath ", which gives the names and addresses of hotels and boarding houses in the locality, with particulars of terms, &c., may be obtained on application to the Secretary.

Rooms have been reserved provisionally at the following, in connection with which the Institute makes no recommendation. All reservations by members and guests must be made direct with the hotels and *not* through the Institute.

Bath Hotels

AA Grading

★★★ Fernley, North Parade (T. 61379).
★★★ Francis, Queen Square (T. 5295).
★★★ Lansdown Grove, Lansdown Road (T. 5891). Rooms not available for full period.
★★★ Pratt's, South Parade (T. 60441).
★★★ Royal York, George Street (T. 61541).
★★ Royal, Manvers Street (T. 61517).
★★ Southbourne, South Parade (T. 60441).
Ap. Cleveland, 55–59 Pulteney Street (T. 3916). Unlicensed.
GH Royal Crescent, 16 Royal Crescent (T. 61803). Unlicensed.

No. AA Grading

Grosvenor, North Parade (T. 5188). Bed and breakfast only. Unlicensed.
Midland, 14 James Street West (T. 302911).
St. Monica's, Pulteney Street (T. 2826). Unlicensed.

Country Hotels

AA Grading

★★ Swan, Bradford-on-Avon (T. 2224).
Ap. Hope Cote, Church Road, Combe Down (T. Combe Down 3235).

Hotels in the following areas would be convenient for Bath for those with cars: Bradford-on-Avon (9 miles); Bristol (13 miles); Chippenham (13 miles); Chipping Sodbury (15 miles); Colerne (7 miles); Combe Down (2 miles).

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Lecture by Professor L. Pauling

Professor LINUS PAULING, of the California Institute of Technology, has accepted an invitation from the Metal Physics Committee to give a lecture under its auspices during his visit to London in July for the Tercentenary Celebrations of the Royal Society. He has chosen as his subject "The Structure of Metals and Intermetallic Compounds". The lecture will be delivered at the Royal Institution, Albemarle Street, London, W.1, at 6.30 p.m. on Monday, 25 July 1960. Visitors are welcome and no tickets are required.

PERSONAL NOTES

DR. M. G. COCKCROFT has resigned his lectureship at Birmingham University and has joined the Plasticity Division of the National Engineering Laboratory, East Kilbride.

MR. S. H. EISNER has been appointed to the Board of Elkington Copper Refiners, Ltd., Walsall, Staffs.

DR. N. GANE has left the U.K. Atomic Energy Authority, Dounreay, and is now a research metallurgist at the A.E.I. Research Laboratory, Aldermaston, Berks.

PROFESSOR A. GUINIER is now at the Service de Physique des Solides, Faculté des Sciences, Université de Paris, Orsay (S. et O.).

DR. MAX HANSEN has been elected to the Board of Vereinigte Deutsche Metallwerke A.G., Frankfurt/Main. He will continue as Managing Director of Metallgesellschaft A.G.

MR. G. HARTLAND-GARRETT has left Allcock and Co. (Metals), Ltd., Birmingham, and joined E. Austin and Sons (London), Ltd., Stanstead Abbots, Herts.

DR. C. W. HAWORTH has left Oxford to become a lecturer in the Department of Metallurgy at the University of Sheffield.

MR. M. E. LANGSTON has left Battelle Memorial Institute to become a metallurgical liaison officer with the United States Air Force in Europe.

DR. T. C. MEAD has left The Mond Nickel Co., Ltd., to become a lecturer in metallurgy at the College of Advanced Technology, Birmingham.

MR. B. B. MORETON has left the Steel Company of Wales to join the Drayton Regulator and Instrument Co., Ltd., West Drayton, Middlesex, as head of the metallurgical and chemical laboratories.

DR. W. A. MUDGE, who was for many years with the International Nickel Co. until his retirement at the end of 1958, has become a Consulting Editor of *Metal Progress*. He has also been appointed an instructor in metallurgy at New York University.

ING. A. OCHI is acting as Technical Consultant to the Companhia Brasileira de Aluminio for a period of two years.

MRS. C. F. TIPPER has resigned her Readership in the Department of Engineering at Cambridge and is now living at Bank House, Langwathby, Penrith, Cumberland.

MR. P. M. UNTERWEISER has been appointed Associate Editor of *Metals Handbook*, published by the American Society for Metals.

LECTURES TO LOCAL SECTIONS

Molybdenum

Dr. L. NORTHCOTT, of the Armament Research and Development Establishment, War Office, lectured on "Molybdenum" to the Sheffield Local Section at its meeting on 24 March, 1960.

He drew particular attention to the high melting point, high modulus of elasticity, high thermal and electrical conductivity, and low specific heat and low coefficient of thermal expansion of molybdenum, compared with the corresponding properties of iron, copper, and aluminium. Dr. Northcott outlined the extraction and reduction processes from molybdenite (MoS_2) to molybdenum powder of particle size ranging from 0·1–6 μ.

He said that until arc melting was introduced some fourteen years ago, molybdenum of high purity had been consolidated by the powder-metallurgy technique. In 1943, Climax Molybdenum Co. had shown that ingots of about 200 lb could be obtained by using a consumable-arc process. More recent furnaces, using multiple electrodes, yielded ingots of 1000 and 2000 lb. Arc melting had advantages over powder metallurgy when large masses of metal were required or where the highest purity was desirable.

The lecturer said that there was no satisfactory method of casting molybdenum to the shapes and sizes required by industry, and for the optimum properties of both arc-melted and sintered molybdenum to be realized a reduction—by working—of about 60% was necessary. Cast molybdenum ingots were worked at temperatures of the order of 1200° C and above, but significant work-hardening occurred and frequent anneals were necessary. The hardness of the metal was such that even at elevated temperatures the amount of deformation per pass was small, though once the cast structure had been broken down subsequent working could be carried out at low temperatures. Heating had to be carried out in a protective atmosphere to avoid significant oxidation of the metal. "Warm" working at 200–400° C was frequently adopted for wire drawing, sheet rolling, and spinning.

The mechanical properties of the material, especially at high temperatures, were discussed and illustrated by slides. Molybdenum alloys had exceptionally high tensile properties and their creep strength exceeded that of conventional creep-resisting alloys. Constitutionally, the alloys of molybdenum fell into two groups: those in which there was complete solid solubility—Mo with W, Ta, Nb, Cr, V, Ti—and those in which there was a peritectic or eutectic series containing one or more intermetallic compounds. In the second group quite small additions had a pronounced hardening and strengthening effect. The tough–brittle transition behaviour was discussed, and it was shown how quite small additions of interstitial elements raised the transition temperature.

The equipment and technique for zone-refining molybdenum, using the electron-bombardment floating-zone melting method, was described. The final bar was usually a single crystal, having a very low transition temperature and a ductility which allowed rolling at room temperature to a reduction of 30% without cracking.

Dr. Northcott said that moderate success had been obtained in the development of oxidation-resistant surface coatings comprising alternate layers of electrodeposited chromium and nickel with a terminal layer of chromium (total thickness 7 mils), whose life had exceeded 500 h at 1100° C. A similar multilayer coating but with nickel outermost, plus an alumina topcoat, had a life exceeding 1100 h at 1100° C.

Semiconductors and Their Applications

At a meeting of the Oxford Local Section on 16 December 1959, Mr. G. M. ETTINGER (Marconi Instruments, Ltd.) gave an account of the "Properties and Applications of Semiconductor Devices".

The history of semiconductor devices, based on the injection and transport of minority charge carriers, was first reviewed. This started with Pierce's paper on crystal detectors (1907), followed by work on copper oxide and selenium rectifiers. Investigation of the properties of germanium crystals led to point-contact microwave detectors and, in 1948, to Bardeen and Brattain's invention of the transistor, comparable in importance to the invention of the thermionic triode by Fleming in 1904.

The physics of practical semiconducting materials was briefly reviewed, a distinction being drawn between the positive temperature coefficient of resistance of metals and the negative coefficient of semiconductors. The effects of impurities on crystal structure were then discussed; these resulted either in excess electrons or in the absence of electrons (positive holes). The concept of mobility of charge carriers was next introduced and the operation of basic *PN* rectifying junctions described, with special reference to the various possible breakdown effects. A discussion of injecting contacts, as employed in transistor triodes, followed, and the factors affecting injection efficiency, and hence transistor gain, were enumerated. After a short account of the methods of growing and refining germanium and silicon crystals, the lecturer described manufacturing techniques for semiconductor devices with alloy or diffused junctions and gave a summary of the types and ratings of transistors being manufactured.

The theory of avalanche devices, such as *PNPN* four-layer diodes, was considered in some detail. These devices appeared likely to replace transistors as well as vacuum tubes for fast pulse applications; switching speeds of the order of 1 mμsec had been obtained.

Finally, some applications of transistor circuits, ranging in power up to several kilowatts, were described and the question of long-term reliability was discussed.

Developments in Mechanical Testing Methods

A Junior Members' Evening was held on the general topic of "Developments in Mechanical Testing Methods" at the Oxford Local Section meeting on 1 March 1960.

There were three speakers, the first being Mr. O. P. HARTREE on **Hot Hardness Testing.**

In the work described, a Vickers indenter was pushed into the material under test for a given time. Hardness was then calculated as the ratio load/area of the plastic impression just before the indenter is removed. It is well known that the hardness of a material is related to its ultimate tensile strength, and as the temperature increases all mechanical properties vary in a similar manner. At a given temperature, hardness, as measured by the penetration of an indenter, is a function of time, as expressed in the relationship:

$$H_2 = H_1 t^{-n},$$

where H_1, H_2 are hardness values separated by a time interval t. The constant n is itself temperature-dependent, increasing in value with increasing temperature.

In testing softer materials, the indenter may be made of sapphire, which has the advantage of relative cheapness. For harder materials, however, diamond must be used, even though trouble may occur owing to reaction between the indenter and the material being tested. Hardness testing was carried out in an evacuated vessel, the load being applied by controlled pressure through flexible bellows.

Allotropic transformations are revealed by discontinuities in the relationship between hardness and temperature in a given metal, e.g. uranium. In recrystallized copper, on the other hand, a continuous relationship exists between the logarithm of the hardness and temperature up to the pre-test annealing temperature. At higher temperatures, hardness values fall below those predicted by a linear relationship.

A rough comparison with other similar materials in terms of creep-resistance may be obtained from the penetration data. Measurement of the strength of tool materials at their working temperature may be made. Precipitation-hardening and softening on annealing may also be studied, using this technique.

Mr. P. M. FRENCH spoke next on **The Mechanical Testing of α-Active Materials.**

The α-active material discussed was plutonium, which oxidizes rapidly in moist air, creating a health hazard. No danger exists from irradiation by massive plutonium, since the penetrating power of α-particles is very small, but once ingested into the body plutonium tends to collect in bone marrow, damaging it by irradiation. Any experimental work on plutonium must be efficiently contained, and this is done in glove boxes, fed with a stream of purified argon at a rate of 10–40 l/min. These glove boxes may either open on to a corridor for cleaning by personnel with "frog suit" protection, or be free-standing, with all services supplied from the laboratory roof, when they are taken to a "frog-suit area" for cleaning. Objects may be put into, or taken out of, the glove boxes in sealed polythene bags, but in some cases two glove boxes may be connected by a wide polyvinyl chloride tube.

Hot hardness tests have been performed on plutonium and certain of its alloys, in high-purity argon, using the Dickens technique. The indentations are made at the required temperatures and the specimen is then allowed to cool to box temperature, when the impressions are measured in the usual manner, i.e. by reading the impression on a focusing screen of the hardness-testing machine. Up to the time of the lecture, tests were not done *in vacuo*, since friction at a moving vacuum seal was thus obviated, a wider temperature range could be used, and the cost was less. Specimens in the shape of cylinders or arc-melted buttons with flats ground on were tested at temperatures up to 800° C.

Tensile testing has been done with an "Instron" testing machine and a Hounsfield tensometer. The "Instron" machine was fitted with a glove box, a polyvinyl chloride "gaiter" taking up the movement of the cross-head. Specimens used had a gauge-length of 1 in. Only the central portion of the Hounsfield tensometer was enclosed within the glove box, leaving free access to the winding handle and plotting drum. All tests were performed in high-purity argon, and consistent results have been obtained only on sheet specimens, with no reduction in area at fracture. Cylindrical specimens, when annealed at a temperature corresponding to the δ modification of plutonium, fractured on machining.

Finally, Mr. J. E. BAINBRIDGE described **The Mechanical Testing of γ-Active Materials.**

The γ-active material tested was irradiated uranium, on which tensile and compressive tests had to be done quickly and safely. The high penetrating power of γ-radiation from the specimens tested required shielding by lead or concrete, and in the experiments described a mixture of these materials was used. As in the testing of α-active materials previously described, an "Instron" tensile testing machine was used. The design of this machine, with completely separate testing frame and operating console, makes it particularly suitable for remotely controlled testing.

The testing frame was surrounded by shielding, and specimens were fitted by using remote handling devices observed through a water-filled window. The test-pieces were made to Specification No. 14, as used with the Hounsfield tensometer, and since an extremely simple specimen grip was necessitated by the remote-handling devices, slotted Nimonic rods were used as chucks. Tensile testing was done over a range from room temperature to 956° C, using a simple rigid furnace for the high-temperature tests in an atmosphere of argon. The ductility of irradiated uranium increases with increasing temperature. Some trouble was experienced with temperature gradients during high-temperature testing, but this non-uniformity of temperature over the specimen was corrected by surrounding it with a copper block. At elevated temperatures, a fire risk is inevitable with uranium, so that specimens were surrounded by a Perspex screen, connected to an extraction fan.

Symposium on "Metallographic Techniques"

After its Annual General Meeting on 7 April, the London Local Section held a symposium on "Metallographic Techniques" consisting of three short contributions: "Some Metallographic Techniques Used in the B.N.F. Laboratories", by M. A. Haughton; "A Reflected-Light Method of Revealing Surface Defects on Metals", by P. J. E. Forsyth; and "Fractography", by D. A. Ryder. An exhibition of photomicrographs was arranged in connection with the symposium. The subject proved very popular and resulted in an unusually large attendance of members and visitors.

OTHER NEWS

Seventh Commonwealth Mining and Metallurgical Congress

The Seventh Commonwealth Mining and Metallurgical Congress will be held in Southern Africa next year. The Congress will last for six weeks, of which the first four weeks, from 10 April to 6 May, will be spent in the Union of South Africa and the remaining two weeks, until 21 May, in Northern and Southern Rhodesia.

A full and varied programme has been arranged to enable delegates to visit not only the great mining and metallurgical undertakings of the three countries, but also the attractive coastal areas and other places of interest, including game reserves, the Victoria Falls, and the Zimbabwe ruins. Technical sessions have been arranged at which about 100 important papers will be presented. Preprints of these papers will be available to all registered delegates three months in advance of the congress.

A second brochure, giving full details of the programmes, including all information on more than twenty major excursions, titles and authors of the papers, and an estimate of costs,

will be published towards the end of April 1960. This publication will be mailed direct to all prospective delegates who replied to the invitation issued with the preliminary brochure which was distributed last year to all who are eligible for membership of the Congress.

Further information may be obtained by writing to the Congress Manager, Seventh Commonwealth Congress, P.O. Box 809, Johannesburg, South Africa.

The Metallurgy of Welding and Brazing

The next Autumn Meeting of the Institute of Welding, to be held in November, will be devoted to the general theme of the metallurgy of welding and brazing. The following papers have been offered for the meeting:

"The Effect of Austenitizing Time and Temperature on Formation of Martensite", offered by the Imperial College of Science and Technology.

"A Critical Appraisal of Cracking Tests", by J. C. Borland.

"The Use of Welding in Chemical Plants in the U.K.A.E.A.", offered by the United Kingdom Atomic Energy Authority, Development & Engineering Group.

"The Quality of Weld Deposits Made by Different Welding Processes", by T. L. Robinson and E. J. Mitchell.

"The Influence of Grain Size on the Properties of Mild-Steel Welds", by Dr. J. Nutting and Dr. D. G. Brandon.

"An Investigation into the Origin of Cracking in Welded Stainless Steel, Using an Autoradiographic Technique", by Dr. P. Pfeil, Mrs. S. Makin, H. R. W. Cobb, and B. Alcock.

"The High-Frequency Induction Brazing of Dissimilar Metals", by J. G. Young.

Members of the Institute of Metals are cordially invited to take part in this meeting.

European Regional Conference on Electron Microscopy

The Nederlandse Vereniging voor Electronmicroscopie announce that the European Regional Conference on Electron Microscopy will be held at Delft from 28 August to 3 September, 1960.

The Conference will deal with the following subjects: the physics and the technique of the electron microscope; image formation; ion-microscopy; preparation techniques; results of ultrastructure research in biology, medicine, chemistry, and metallography.

The official languages are English, French, and German.

Any one contemplating attending should write as soon as possible for fuller details to: Dr. A. L. Houwink, Secretary, European Regional Conference on Electron Microscopy, Laboratorium voor Microbiologie, Julianalaan 67a, Delft, Netherlands.

APPOINTMENTS VACANT

FULMER RESEARCH INSTITUTE LIMITED

Requires PHYSICAL CHEMISTS, METAL PHYSICISTS, and METALLURGISTS equivalent in status to Scientific and Senior Scientific Officers, to work on fundamental properties and structures of alloys, including those of aluminium, zirconium, and uranium.

Candidates should be of honours degree standard and preferably have some research experience. For one of the posts experience in Electronics would be an advantage.

Applications should be addressed to:
Director of Research,
Fulmer Research Institute Ltd.,
Stoke Poges,
Buckinghamshire.

RESEARCH MANAGER required for Metallurgical laboratories o Works producing special nickel and copper based alloys, situated south of London. The job involves controlling the activities of a number of Graduates and their teams developing new and existing alloys and manufacturing techniques. The position is one of importance and considerable interest and the salary will depend upon qualifications and experience, but will be not less than £1500 a year. Applicants should be about 35 years old and hold an Honours Degree in Metallurgy with, preferably, a post-graduate degree and some Industrial experience. Local housing accommodation could be made available. Please write in confidence, giving full details of experience, qualifications, salary, &c., to Box No. 456, The Institute of Metals, 17 Belgrave Square, London, S.W.1.

UNIVERSITY OF DURHAM

KING'S COLLEGE, NEWCASTLE UPON TYNE

Durham Chemicals Memorial Studentship

Applications are invited for the above-mentioned Studentship, of the value of £350 p.a. with remission of composition fee, which is available for postgraduate research in the Departments of Metallurgy and Chemistry.

The Studentship is open to graduates of an approved University, or holders of approved qualifications who have shown, or seem likely to show, ability as a research worker. It is tenable for two years, but may be renewed for a third year in special circumstances.

Forms of application and further particulars may be obtained from the undersigned, to whom completed application forms should be returned as soon as possible.

G. R. HANSON
Registrar of King's College

TECHNICAL OFFICER, age 25–40, preferably a graduate metallurgist or chemist, required for liaison work dealing with the application of zinc coatings for corrosion prevention.

Applications to the Director, Zinc Development Association, 34 Berkley Square, London, W.1.

COLLEGE OF ADVANCED TECHNOLOGY BIRMINGHAM

DEPARTMENT OF METALLURGY

Applications are invited for the post of

SENIOR LECTURER IN METALLURGY

Candidates should have an honours degree or equivalent and have appropriate industrial and/or teaching experience

Salary Scale:

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Further particulars and forms of application from the Bursar, College of Advanced Technology, Gosta Green, Birmingham, 4. Applications to be received within 14 days of this advertisement. Please quote 'O'

K. R. PILLING, *Clerk to the Governors.*